Review of Zhang et al. "Hybrid Modeling on 3D hydraulic features of a step-pool unit." – Version 2

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This revision is a great improvement on the initial submission. The entire paper is more clearly written, more technically accurate and more authoritative. I would like to congratulate the authors again on this paper. This paper contains some novel and excellent data and some important conclusions and it deserves and needs to be published. I would also like to thank the authors for responding positively and constructively to my comments. However, that said, I still have some concerns over terminology and the description of results – although this aspect shows a distinct improvement on the first draft – and it needs further revision, although much more minor than the first revision. I shall discuss this concern in detail first, and then list general comments.

The word "regime" is misused at several places. Line 230; the "water surface regime" probably did not change during the experiment (it would always have been the plunging jet regime), so it's not clear what was measured here. Line 235; the jet and the jump are flow structures or components or regions of flow, not flow regimes. Line 284; "Plunging jet" (Wu & Rajaratnam 1998) is a flow regime and refers to a type of flow over a vertical drop, consisting of a jet plunging into a hydraulic jump. This regime contrasts with the surface flow regime over a drop in which the jet travels horizontally and enters an oscillatory jump. However a jet is not a flow regime so it is incorrect to say that "flow accelerates… before plunging into the pool as the jet regime."

Lines 284-286. This is a misinterpretation. This description gives the impression that the region of high flow velocity moves from the upper part of the flow to the lower part. In fact, the position of the region of high flow velocity remains unchanged in the upper part of the flow and the step stones protrude upwards into it.

Line 293. The word "wake" is still misused. The region at the toe of the step cannot be described as a wake. See my comments on the use of "wake" in my review on the first draft.

Lines 308-309. It is not evident from Figure 5 that high velocity regions occur at the low points in the step crest.

Line 339. Why does flow velocity decrease with an increase in discharge? This is counterintuitive.

Line 366 and Figure 8. Surely these are time-averaged turbulent coherent structures, not instantaneous ones? Although the authors state that the structures illustrated in Figure 8 are instantaneous, the description that follows in the text is of time-averaged structures, and certainly it is only the persistent, time-averaged structures that are relevant to the study.

Line 367. What does "streamwise coherent structures" mean? This is vague. What type of structure are they?

Lines 23, 369 and 444. The vortices at the step toe are described as "streaky". This adjective is applied to structures that are highly elongated in the streamwise direction, which these vortices are not.

Lines 373-375. This description of curvature in the recirculation cell of the hydraulic jump correlating with the positions of step toe vortices is not convincing. If you decide to stick with it, I recommend replacing "upper bends" and "downward bends" with "convex-upwards curvature" and "convex-downwards" curvature respectively.

Lines 400-404. I suggest that, rather than the shape and maximum height of the step stones influencing the distribution of shear stress, it is the presence of the step toe vortices. The downstream curvature of the high shear stress zone you mention on the upper faces of the step stones matches the boundary of the step toe vortices as shown in Figure 8.

Lines 429-435. Is it necessary to present drag and lift coefficients as well as drag and lift forces? It does not seem to add anything to the interpretation of step failure and stability.

Line 455. This is a misinterpretation of the surface flow regime. These experiments did not generate the surface flow regime because there was always a hydraulic jump across the entire flume width. However, I agree that the fact that in some longitudinal sections the jet did not impinge on the pool bottom indicates that (1) the Q=49.9 l/s discharge is probably transitional between the impinging jet and surface flow regimes, and (2) this indicates that the flow regime over a step is not necessarily binary (i.e. either impinging jet or surface flow).

Lines 486-487. This statement is not apparent from Figure 13. Also, why do the values for the step toe vortex not drop to zero downstream of the end of the vortex?

I shall now list general comments.

Line 20. Replace “by” with “from”.

Line 24-25. Replace “with comparable capacity” with “of comparable magnitude”.

Line 26. Replace “increase” with “expansion”.

Line 27. Delete “as”. Place “grain clusters” in parentheses.

Lines 34 and 37. “Benefits” and “advantages” are subjective terms.

Line 45. What type of products?

Line 56 Semi-colon rather than comma required after “morphology”.

Line 65. Delete “(the lowest area in the pool)”.

Line 89. Replace “experimental” with “physical”.

Line 107. Is the superscript “2” required on “px^{2}”?

Line 111. It would be helpful to report D_{100} and D_{84} as well.

Line 112. What discharge is the Froude scaling based on, and why was Froude scaling (rather than some other scaling method) chosen?

Line 117. Change “the step” to “the model step”.

Figure 2. “L/s” should be “l/s”.

Line 125. What are T runs?

Line 133. Insert “for discharges < 56.1 l/s” after “CIFR T2”.

Lines 152-153. Insert “all” after “characterize”. Replace “e.g.” with “including for example”.

Lines 184-185. “The gravity model was activated…” Is this sentence necessary?

Line 223. 2 Hz and 30 s are a low sampling frequency and period respectively. This sampling strategy cannot capture high frequency velocity fluctuations. What are the implications of this for the results?

Line 244. Replace “in three directions” with “and the subscripts denote the respective coordinate axis”.

Line 246. Delete “in three directions”.

Lines 247-248. “Q-criterion” notation should be consistent. Replace “calculate and visualize” with “identify”. How was the threshold value of 1200 selected?

Line 253. Replace P_s with P_d.

Line 267 and 270. Replace “taken” with “occupied”.

Lines 281. Insert “mean” before “flow velocity” in title.

Line 289-290. Change “the” to “a” in “the recirculation cell”. Insert “associated with a hydraulic jump” after “water surface”. Insert “associated with an attached vortex” after “step toe”. Delete “sliding”.

Line 296. Replace “reduction” with “contraction”.

Line 308. Replace “locate” with “are located”.

Lines 319-321. Confusing sentence.

Line 329. Replace “with” with “as those in”.

Line 330. Replace “are” with “is”. Replace “at a much lower level if compared with” with “lower than in”.

Line 331. I suggest replacing this sentence with “These areas of low TKE coincide with areas of high mean flow velocity”. Indeed, would it be simpler to state that Mean flow velocity and TKE are inversely correlated in general?

Line 332. Insert “Like mean flow velocity,” at the start of this sentence.

Line 333. Replace “above the bed surface” with “within the attached vortices”.

Line 334-335. Move “both” to after “recirculation cells”. Insert “at the” after “”water surface and”.

Line 335-336. Replace “and much higher TKE is contained…” with “although that in the recirculation cell above the jet is much higher”.

Line 346, 353, 368. Replace “at the downstream area of the” with “downstream of”.

Line 366. Replace “In the upstream area of” with “upstream of”.

Line 368. Replace “as a combination of” with “in both the”.

Line 369. Insert “the” after “water surface and”.

Line 372-373. Replace “A near bed vortex starts” with “The vortices at the step toe start”. Replace “its” with “their”. Delete “to the” and “direction”. Replace “vortex vanishes” with “vortices vanish”.

Line 376-377. Replace “do not show streaky features as they do” with “are not elongated in the streamwise direction as they are”.

Line 387. Replace “flow” with “jet”.

Line 399. Delete “The step stones bear the highest level of shear stress in the step-pool unit”. This sentence is basically repeated in the next sentence.

Lines 403-404. Replace “The edges of the” with “There is also a”. Replace “in the back sides” with “on the downstream faces”. Replace “show clear” with “with a”.

Line 405. Replace “flow” with “jet”.

Line 445. Replace “different” with “as distinct”.

Line 448. Replace “will be followed by the” with “generate”.

Line 452. Delete “eventually”.

Line 465. Insert “of the profile” after “middle”.

Line 467. Replace “of the flow for” with “within”.

Line 470. Move “both” to after “distributions of”.

Line 474. “Appealingly” is not appropriate.

Line 478. Insert “section” before “-averaged”.

Line 486. Insert “section” before “integral”.

Line 489. Insert “cell” after “recirculation”.

Line 490. Replace “one” with “vortex”. Insert “at 43.6 l/s” after “near the water surface”.

Line 491. Replace “below” with “of”.

Line 492. Replace “intensification of” with “increase in”.

Line 494. Replace “is enlarged” with “increases”. Insert “at high discharges” after “pool development”.

Line 499. Replace “concentrates” with “occurs”.

Line 501. Replace ”local” with “pool”.

Line 504. Replace “a drop as well as the pool at the downstream” with “an artificial 2D drop”

Line 513-514. Replace “in the pool” with “of the step”.

Line 520-522. Is this noteworthy?

Line 526. “The grain clusters at the pool bottom…”. This sentence is a tautology.

Line 531. How is the distribution of micro-bedforms at the pool bottom affected by the jet?

Line 548. The variation in the direction of the lift force is unlikely to be “sudden”.